NATIONAL REPORT
OF
BRAZIL

NUCLEAR SAFETY CONVENTION

September 1998

FOREWORD

On September 24 1994 the Convention on Nuclear Safety was opened for signature at the headquarters of the International Atomic Energy Agency in Vienna. Brazil signed the Convention in September 1994, approved it through the legislative decree n. 4 of January 22 1997 and deposited the instrument of ratification with the Depositary on January 24 1997.

The main objective of the Convention is to achieve and maintain a high level of nuclear safety throughout the world. One of the obligations of the parties to the Convention is the preparation of a National Report describing the national nuclear programme, the nuclear installations involved according to the definition established by the Convention, and the measures taken in order to fulfill the objectives of the Convention.

This National Report was prepared by a group composed of representatives of the various Brazilian organizations with responsibilities in the field of nuclear safety, as a means of fulfilling this Convention's obligation. The Report contains a description of the Brazilian policy and programme on the safety of nuclear installations, and an article by article description of the measures Brazil is undertaking in order to implement the obligations described in the Convention. A final chapter describes plans and future activities to further enhance the safety of nuclear installations in Brazil.

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NATIONAL REPORT OF BRAZIL

Chapter 1. INTRODUCTION

1.1. The Brazilian nuclear policy

The current Brazilian Federal Constitution of 1988 states in Articles 21 and 177 that the Union has exclusive jurisdiction over managing and handling all nuclear energy activities, including the operation of nuclear power plants. The Union also holds the monopoly in the survey, mining, milling, exploitation and exploration of nuclear minerals, as well as the activities related to the industrialization and trade of nuclear minerals and materials. All these activities shall be solely carried out for peaceful purposes and always under the approval of the National Congress.

The national policy for the nuclear sector is implemented through the Plan for Science and Technology 1996/1999 (Plano Plurianual de Ciencia e Tecnologia - PPA 1996/1999), which establishes the quantitative targets of the Government's strategy. Among these targets is the National Nuclear Power Policy, aiming at guiding research, development, production and utilization of all forms of nuclear energy considered to be of strategic interest for Brazil in every respect, including the scientific, the technological, industrial and commercial applications, energy production, civil defense, public safety and the environment.

Another important target is to increase the role of nuclear energy in the national production of electricity. This involves continually developing technology, and designing, constructing and operating nuclear industrial facilities related to the nuclear fuel cycle. It also includes the technological and industrial capability to design, construct and operate nuclear power plants, in order to provide electrical energy to the Brazilian grid in a safe, ecologically sound and economical way. Moreover, this also requires the development of necessary human resources for the establishment and continuity of the activities in all these fields.

The Brazilian National Commission for Nuclear Energy (Comissão Nacional de Energia Nuclear - CNEN) was created in 1956 (Decree 40.110 of 1956.10.10) to be responsible for all nuclear activities in Brazil. Later, CNEN was re-organized and its responsibilities were established by Law 4118/62 as amended by Laws 6189/74 and 7781/89. Thereafter, CNEN became the Regulatory Body in charge of regulating, licensing and controlling nuclear energy, whereas nuclear electric generation was transferred to the electricity sector.

1.2. The Brazilian nuclear programme

Currently, Brazil has a nuclear power plant in operation (Angra 1, 657 MWe gross/626 MW net, PWR), and two under construction (Angra 2, 1312 MWe gross/1229 MW net, PWR and Angra 3, similar to Angra 2). The construction of Angra 3 was temporarily interrupted but has been taken up again, in light of the critical situation of energy supply in Brazil. Angra 1, 2 and 3 are located at a common site, near the city of Angra dos Reis, some 130 km from Rio de Janeiro.

The construction of nuclear power plants in Brazil required great efforts in qualifying domestic engineering, manufacturing and construction firms, so as to comply with the strict standards for nuclear technology transfers. The result of these efforts, part of on active process of transfer of technology, has led to an increasing domestic participation in the production.

Brazil has established a nuclear power utility/ engineering company Eletrobras Termonuclear S. A. (ELETRONUCLEAR), a heavy components manufacturer, Nuclebras Heavy Equipment (Nuclebras Equipamentos Pesados - NUCLEP), a nuclear fuel manufacturing plant (Fuel Element Factory - FEC), and a yellow-cake production plant belonging to Nuclear Industries of Brazil (Industrias Nucleares do Brasil - INB). Brazil also has the basic technology for Uranium conversion and enrichment, as well as private engineering companies and research and development (R&D) institutes and universities devoted to nuclear power development. Over 15,000 individuals are involved in these activities. Brazil ranks sixth in world Uranium ore reserves which amounts to approximately 310,000 t U_3O_8 in situ, recoverable at low costs.

According to the long-term plan for the electric power sector, three different scenarios are being considered for the year 2015. The first one, predominantly based on hydro resources does not foresee the construction of any new nuclear power plant. In the second, which has a strong thermal component, four additional nuclear power plants would be connected to the grid in the years 2009, 2011, 2013 and 2015. The third scenario, considered to be the 'recommended' one, foresees the inauguration of two additional nuclear units, one in 2011 and the other in 2013.

1.3. Structure of the National Report

This National Report was prepared to fulfill the Brazilian obligations under the Convention on Nuclear Safety [1]. Chapters 2 to 5 follow the Guidelines for the preparation of National Reports [2] and present an article by article analysis of the Brazilian framework, actions and activities related to the Convention's obligations (Chapter 2 of the Convention). In Chapter 2 some details are given about the existing nuclear installations. Chapter 3 provides details about the legislation and regulations, including the regulatory framework and the regulatory body. Chapter 4 covers general safety considerations as described in articles 10 to 16 of the Convention. Chapter 5 addresses to the safety of the installations during siting, design, construction and operation. Chapter 6 describes planned activities to further enhance nuclear safety. Chapter 7 presents final remarks regarding the degree of compliance with the Convention's obligations.

Since Brazil has only one nuclear installation in operation and two under construction, more plant specific information is provided in the report than is recommended in the

Guidelines [2]. This was intentionally done for the benefit of the reader not familiar with the current Brazilian situation.

The report also contains a series of annexes where more detailed information is provided with respect to the nuclear installations, the Brazilian nuclear legislation and regulations and relevant technical reports. Organizational charts of relevant organizations are presented as attachments.

Chapter 2. NUCLEAR INSTALLATIONS

2.1. Article 6. Existing nuclear installations

As mentioned in item 1.2, Brazil has a nuclear power plant in operation (Angra1, 657 MWe gross/626 MW net, PWR) and two under construction (Angra 2, 1309 MWe gross/1229 MW net, PWR and Angra 3, similar to Angra 2, whose construction has been temporarily halted). Angra 1, 2 and 3 are located at a common site, near the city of Angra dos Reis, some 130 km from Rio de Janeiro. More details about these units can be found in Annex 1 or in the PRIS [3], available through the Internet.

2.1.1. Angra 1

Site preparation for Angra 1, the first Brazilian nuclear unit, started in 1970 under the responsibility of FURNAS Centrais Eletricas SA. The actual construction of the plant began, however, only in 1972, shortly after the contract with the main supplier of equipment, Westinghouse Electric Co. (USA), was signed. The Westinghouse contract included supply and erection of the equipment, as well as engineering and design of the plant on a turnkey basis. Westinghouse sub-contracted Gibbs and Hill (USA) in association with the Brazilian engineering company PROMON Engenharia S.A. for engineering and design. For the erection work, Westinghouse brought in a Brazilian contractor, Empresa Brasileira de Engenharia S.A. (EBE). For the supply of the containment steel structure and the civil works not included in the Westinghouse contract, FURNAS hired directly, respectively, the Chicago Bridge & Iron Company and Construtora Norberto Odebrecht S.A, a Brazilian contractor who eventually also became contractor of the civil works for Angra 2. To assist in the implementation of the overall quality assurance programme, FURNAS hired an independent consultant, Ebasco Services Co. To assist in the implementation of the nuclear fuel quality assurance programme, NUS Corporation was contracted as independent consultant.

CNEN granted the construction permit for the plant in 1974. The operating licence was issued in September 1981, when the first fuel core was also loaded. First criticality was reached in March 1982, and the plant was connected to the grid in April 1982.

After a long commissioning period due to a steam generator generic design problem, which entailed modifying some of the equipment, the plant finally began to operate commercially on January 1st, 1985. After a good operating record in 1985, some forced outages and operational problems related to the secondary side were experienced during the period 1986- 1987, culminating in a forced outage due to the electric generator stator's burnout, which entailed its complete reconstruction. After this main repair, which took about 16 months, the plant resumed operation late in 1988 and operated with high availability until 1993, when a significant fuel failure occurred. After repair performed by the fuel supplier that took about one year, the plant operated during the period January- December 1995 with high availability (some 90%), and remained synchronized in the grid during 337 days. Since the last fuel reload, the plant has been operating with high availability. Angra 1 is very important for ensuring a reliable power supply to the state of Rio de Janeiro which imports some 70% of its electricity needs from long distance hydro power plants. The plant also plays a fundamental role in supplying reactive power to the system near the main load consumption centers, thus becoming a valuable factor in the reliable operation of the interconnected system.

Plant ownership has recently been transferred to the newly created company ELETRONUCLEAR, which has absorbed all the operating personnel of FURNAS, and part of its engineering staff, and the personnel of the design company Nuclebras Engenharia (NUCLEN).

The personnel in charge of all modifications and improvements carried out since the first connection of the plant to the grid, from FURNAS, NUCLEN (now both at ELETRONUCLEAR) and other engineering companies, acquired considerable experience in dealing with different technical problems.

2.1.1.1. Safety improvements at Angra 1.

The safety status of Angra 1 had been under constant review by FURNAS, and continues to be reviewed by ELETRONUCLEAR. Plant safety upgradings have been carried out during the life of the installation. Major upgrading programmes, still during the construction phase, were carried out following significant events in similar plants, such as the fire at Browns Ferry NPP and the accident at Three Mile Island. In addition, a comprehensive review of the accident analysis was carried out following changes in the designer models due to new requirements established in the Appendix K of the US regulation 10CFR50, in 1976.

During operation, Angra 1 has been reviewed and upgraded according to its own operational experience, to new CNEN requirements, and to the review of international experience in similar plants. Major upgrades refer to the installation of new Titanium condenser tubes, the addition of two new Diesel generators, and items related to the lessons learned from the Three Mile Island accident such as a safety parameters display system, venting on the top of the reactor vessel, on-line monitoring of H_2/O_2 in the containment, and post- accident sampling capability. Modifications related to the evolution of nuclear technology include the replacement of battery banks, installation of anticipated transient without scram (ATWS) mitigation system, cold overpressurization protection, new portal monitors in the controlled area, and new compact storage racks at the spent fuel pool (a detailed list of modification carried out at the Angra 1 plant is presented in Annex 3). On the analysis side, a preliminary Probabilistic Safety Analysis (PSA) was conducted using generic plant data. A new study is being conducted to take into account actual plant data, human reliability analysis, and additional events such as fire and flooding.

2.1.2. Angra 2 and 3

Angra 2 and 3, 1309 MWe gross/1229 MW net PWRs, using SIEMENS/KWU technology are under construction with a high degree of technology transfer, according to the framework established by the Brazilian-German Agreement on Peaceful Uses of Nuclear Energy signed in 1975. Their commercial operations, according to present ten-year expansion programme of the power sector, are to take place in 1999 and 2005, respectively. These two units, whose commercial operation was scheduled to begin in the mid-eighties, suffered various delays due to economic and financial difficulties faced by Brazil from 1983 onwards.

Considering that one of the objectives of the Brazilian-German Agreement was a high degree of domestic participation, the construction of Angra 2 and 3 required great efforts in qualifying Brazilian engineering firms and local industry so as to comply with the strict standards of nuclear technology. Indeed, this allowed for a growing participation of national companies (engineering firms, equipment industries, erection firms, testing laboratories and so on) in this major undertaking, always under the conditions that the same level of safety be attained as in similar plants found in of the technology supplier country.

As of December 31, 1997, the construction of Angra 2 is 88 % complete. The base foundation of Angra 3 has not been started yet, but all its main components are already in Brazil and the site is ready for the pouring of concrete. Engineering is practically complete, since Angra 3 is to be identical to Angra 2.

Chapter 3. LEGISLATION AND REGULATION

3.1. Article 7. Legislative and regulatory framework

Brazil has established and maintained the necessary legislative and regulatory framework to ensure the safety of its nuclear installations. The Federal Constitution of 1988 specifies the distribution of responsibilities among the Union, the federal states and the municipalities with respect to the protection of the public health and the environment, including the control of radioactive products and installations (Articles 23, 24 and 202). As mentioned in item 1.1, the Union is solely responsible for the nuclear activities related to electricity generation, including regulating, licensing and controlling nuclear safety (Articles 21 and 22). In this regard, the Brazilian National Commission for Nuclear Energy (Comissão Nacional de Energia Nuclear - CNEN) is the national regulatory body, in accordance with the National Nuclear Energy Policy Act.

Furthermore, the constitutional principles regarding protection of the environment (Article 225) establish that any installation which may cause significant environmental impact shall be subject to environmental impact studies that shall be made public. More specifically, for nuclear power plants, the Federal Constitution provides that the siting of the installation shall be approved by law (Article 225, Paragraph 6). Therefore, licensing of nuclear power plants are subject to both a nuclear licence by CNEN and an environmental licence by the Brazilian Institute for the

Environment and Renewable Natural Resources (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis - IBAMA), with the participation of state and local environmental agencies as provided by the National Environmental Policy Act.

These principles were established by the Federal Constitution of 1988, at a time when Angra 1 was already in operation, and Angra 2 was already under construction. Therefore, licensing procedures for these power plants followed procedures slightly different from the ones described below.

3.1.1. Nuclear licensing process

CNEN was created in 1956 (Decree 40.110 of 1956.10.10) to be responsible for all nuclear activities in Brazil. Later CNEN was re-organized and its responsibilities were established by the Law 4118/62 as amended by Laws 6189/74 and 7781/89. Thereafter, CNEN became the Regulatory Body in charge of regulating, licensing and controlling nuclear energy.

CNEN's responsibilities relating to this Convention include, among others, the following activities:

- the preparation and issuance of nuclear safety, radiation protection, radioactive waste management and physical protection regulations;
- accounting and control of nuclear materials (safeguards);
- licensing and authorization for siting, construction, operation and decommissioning of nuclear facilities;
- regulatory inspection of nuclear reactors;
- acting as a national authority for the implementation of international agreements and treaties concerning nuclear safety activities;
- participating in the national preparedness for, and response to nuclear emergencies.

Under this framework, CNEN has enacted radiation protection regulations and regulations for the licensing process of nuclear power plants, safety during operation, quality assurance, licensing of operational personnel and their medical certification for active duty, reporting requirements for the operational nuclear power plants, plant maintenance, among other things (See Annex 2. Item 2.3 for a complete list of CNEN regulations).

The licensing regulation CNEN NE 1.04 [4] establishes that no nuclear installation shall operate without a licence. It also establishes the necessary review and assessment process, including the specification of the documentation to be presented to CNEN at each phase of the licensing process. It finally establishes a system of regulatory inspections and the corresponding enforcement mechanisms to ensure that the licensing conditions are being fulfilled. The enforcement mechanisms include the authority of the CNEN to modify, suspend or revoke the licence.

The licensing process is divided into several steps:

- o Site Approval;
- o Construction Licence;
- o Nuclear Material Utilization Authorization;
- o Authorization for Initial Operation;

- o Authorization for Permanent Authorization;
- o Authorization for Decommissioning

For the first step, site selection criteria are established in Resolution CNEN 09/69[5], considering factors such as the design and the site itself, which may contribute to violation of established dose limits at the proposed exclusion area for a limiting postulated accident. Additionally, by adopting the principle of "proven technology", CNEN's regulation NE 1.04 requires, for the site approval, the adoption of a "reference plant" for the nuclear installation being licensed.

For the construction licence, CNEN performs a detailed review and assessment of the information received from the licensee in a Preliminary Safety Analysis Report (PSAR). The construction is followed closely by a system of regulatory inspections.

For the authorization of initial operation, CNEN reviews the construction status, the commissioning programme including results of pre-operational tests, and updates its review and assessment of plant design based on the information submitted in the Final Safety Analysis Report (FSAR). At this time CNEN also licenses the reactor operators in accordance with regulation NE 1.01 [6]. Startup and power ascension tests are closely followed by CNEN inspectors, and hold points at different power levels are established.

Authorization for permanent operation, which is limited to a maximum of 40 years, is awarded only given after a complete review of commissioning test results has been completed, and the deficiencies identified during construction and initial operation have been solved. The authorization establishes limits and conditions for operations and lists the programmes which should be kept active during operation, such as the radiological protection programme, the physical protection programme, the quality assurance programme for operation, the fire protection programme, the environmental monitoring programme, the qualification and training programme, the preventive maintenance programme, the retraining programme, etc. Reporting requirements are also established through CNEN regulation NE 1.14[7]. These reports, together with a system of regulatory inspections performed by resident inspectors and headquarters personnel are the basis for monitoring the safety of plant operation.

Other governmental organizations are involved in the licensing process, through appropriate consultations. The most important ones are the Institute for Environmental and Renewable Natural Resources (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis - IBAMA), which is in charge of environmental licensing and the Secretariat for Strategic Affairs (Secretaria de Assuntos Estratégicos - SAE) which is involved in emergency planning aspects.

3.1.2. Environmental licensing

IBAMA was created through Law n. 7.735 of 22 February 1989 under the Ministry for Environment, Hydro Resources and the Legal Amazonia (Ministério do Meio Ambiente, Recursos Hídricos e da Amazonia Legal - MMA) with the responsibility to execute and enforce the National Environmental Policy (PNMA) established by the Law N^{o}. 6938/81.

The PNMA established the National System for the Environment (SISNAMA), which is composed by the National Council for the Environment (Conselho Nacional para o Meio Ambiente - CONAMA) and executive organizations at the federal, state and municipal levels. The central executive body for SISNAMA is IBAMA, which is, therefore, responsible for the environmental licensing process of any installation with potential significant environmental impact. This involves the development of an Environmental Impact Study (EIA) and the preparation of an Environmental Impact Report (RIMA), which is made available to the public and discussed in a public hearing, according to the national legislation (see Annex 2, item 2.4 for list of CONAMA regulations).

Actually, the environmental licensing of Angra 1 took place before the creation of IBAMA, at the time that the State Foundation for Environment Engineering (Fundação Estadual de Engenharia do Meio Ambiente - FEEMA) was the state organization in charge of environmental matters.

Since 1989, after the establishment of the legal competence of IBAMA for environmental licensing of nuclear installations, with the participation of CNEN and state and local environmental agencies, the Institute became involved with the licensing of Angra 2. Although Angra 2 was already under construction, IBAMA has required from FURNAS, now ELETRONUCLEAR, the preparation of an Environmental Impact Study (EIA) and a Report on Environmental Impact (RIMA) for the operation environmental licence.

Since CNEN has the technical competence for the evaluation of radiation impact on the environment, IBAMA and CNEN have established a formal agreement to specify their respective areas of activity so as to optimize both licensing processes (see also 5.1).

3.1.3. Emergency preparedness legislation

With respect to emergency preparedness additional requirements have been established by the creation of the System for Protection of the Brazilian Nuclear Programme (SIPRON) through Law 1809 of October 7 1980. The subsequent decree 2210 of April 22 1997 has defined the Secretariat for Strategic Affairs (Secretaria de Assuntos Estratégicos - SAE), directly linked to the Presidency, as the central organization of SIPRON that is responsible for preparedness and the response to nuclear emergencies in Brazil (see diagram in Attachment 1E). This decree also establishes the system's structure: its organization, the agencies involved and the Commission for Protection of the Nuclear Programme (COPRON) as the coordinating mechanism.

SIPRON guidelines, set forth by COPRON (see Annex 2, item 2.5), require that ELETRONUCLEAR prepare, keep up- to- date and exercise a plan for nuclear emergency situations. As a matter of fact, the guidelines require CNEN and other organizations and agencies involved to have their own emergency plans, as well (see item 4.7).

3.2. Article 8. Regulatory body

As mentioned in item 3.1, the Brazilian National Commission for Nuclear Energy (CNEN) has been designated as the regulatory body entrusted with the implementation of the legislative framework related to safety of nuclear installations. However, other governmental bodies are also involved in the licensing process, such as the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA).

CNEN authority is a direct consequence of Law 4118/62 as amended by Laws 6189/74 and 7781/89, which creates CNEN. These laws established that CNEN has the authority "to issue regulations, licences and authorizations related to nuclear installations", "to inspect licensed installations" and "to enforce the Laws and its own regulations".

Financial resources for CNEN are provided directly by the Government budget. Currently, the licensee is not charged fees or taxes. A bill of law establishing licence fees and taxes is under discussion in the National Congress.

The structure of CNEN is provided in Attachment 1B. The main organizational unit involved with the licensing of nuclear power plants is the Directorate for Radiation Protection and Nuclear Safety (DRS), although technical resources can be drawn from any other units. Review and assessment is performed mainly by the Reactor Coordination (CODRE) of the Superintendence for Licensing and Control (SLC). CODRE is also in charge of regulatory inspection of nuclear power plants, including a group of resident inspectors at the Angra site. In the areas of radiation protection and environmental monitoring technical support is obtained from the Institute for Radiation Protection and Dosimetry (IRD). The necessary regulations and standards are developed by working groups under coordination of the Norms Service (SENOR).

Adequate human resources are provided to CNEN. A total staff of 2756 employees, of which 85% are technical staff, is available at CNEN and its research institutes. Forty- eight percent

(48%) of the staff are university graduates, 17% having a master degree and 7% having a doctoral degree. SLC itself comprises 183 individuals, 149 of which are technical personnel. CODRE, the unit directly involved with nuclear power plants, has a staff of 42, of which 40 are technical, of which 20 possessing a doctoral or master degree in nuclear science or engineering.

Effective separation between the functions of the regulatory body (CNEN) and the organization responsible for the promotion and utilization of nuclear energy for electricity generation (ELETRONUCLEAR) is provided by the organizational structure of the Brazilian Government itself. While CNEN is subsidiary body of SAE, which is directly linked to the Presidency of the Republic, ELETRONUCLEAR is a part of ELETROBRAS, a national holding company for the electric system, which is subordinated to the Ministry of Mines and Energy (Minstério de Minas e Energia - MME) (see Attachment 1A).

The licensing structure of IBAMA (see Attachment 1D) comprises its Department of Project Evaluation, with a graduated technical staff of 18 professionals and 7 technicians. For the licensing of Angra 2, they work in close cooperation with CNEN staff concerning the radiological impact aspects. They also cooperate with the Rio de Janeiro State Foundation for Environmental Engineering (FEEMA) and the Angra dos Reis Municipal Secretary for Environment.

3.3. Article 9. Responsibility of the licence holder

The Brazilian regulation ascribes to the operating organization the prime responsibility for the safety of a nuclear installation.

ELETRONUCLEAR, as the owner and operator of the Angra plant, has issued a company policy statement regarding its commitment to safe operation, which reads as follows:

> **"Safety is a priority that precedes production and economics. Safety shall never be jeopardized for any reason"**
>
> It further states that:
>
> **"Responsibility for safety is shared equally by the entire corporate structure - Directors, Advisors, Superintendents, Managers and Divisions Heads. Careless acts or actions by employees do not diminish the responsibilities of their supervisors".**

The text of this company policy statement, reproduced in its original Portuguese version in Attachment 2, is fully based on the IAEA INSAG-4 publication on Safety Culture.

The implementation of this policy is based on a programme that adopts the concept of Safety Culture, defines safety objectives and establishes requirements, appropriate management structure (Attachment 1C), resources and self-assessment.

CNEN, through the licensing process, and especially through its regulatory inspection programme, ensures that the regulatory requirements for safe operation are being fulfilled by the licensee. The licensee reports periodically to CNEN in accordance with regulation CNEN-NE-1.14 [7]. In addition, CNEN maintains a group of resident inspectors on the site, who can monitor licensee performance on a daily basis. Finally, a number of regulatory inspections by headquarters staff take place every year, focusing on specific topics or operational events.

Chapter 4. GENERAL SAFETY CONSIDERATIONS

4.1. Article 10. Priority to safety

ELETRONUCLEAR is the product of a merger between the nuclear area of the electric energy utility FURNAS and the nuclear engineering company NUCLEN, both of which had operated for more than 20 years in their fields. Both companies traditionally had policies aiming at giving priority to nuclear safety.

At the time of the merger, one of the first acts of the new company ELETRONUCLEAR was the approval by the Board of Directors of a document formally establishing the priority attributed by the company to the safety of the installations (Attachment 2). As mentioned above, the safety policy statement establishes that "Safety is a priority that precedes production and economics. Safety shall never be jeopardized for any reason."

To ensure that this policy is being implemented, ELETRONUCLEAR has established a Committee for Nuclear Operation Analysis (CAON), which is responsible for reviewing activities relating to nuclear safety. Furthermore, the Quality Assurance unit (PL), which monitors all design, construction and operation activities, reports directly to the President of ELETRONUCLEAR (see Attachment 1C).

CNEN has also issued a safety policy statement in December 1996, which is equally based on the concept of safety culture.

4.2. Article 11. Financial and human resources

4.2.1. Financial resources

As a governmental enterprise, the financial situation of ELETRONUCLEAR is subordinated to the holding company ELETROBRAS, which controls all federal electric utilities in Brazil. Adequate funds for operation and maintenance of the Angra 1 plant are made available through the annual budget, which includes the plant upgrading programme. Adequate funding for the construction of Angra 2 has also been assured. Funding for the completion of Angra 3 are still under discussion.

In spite of the current privatization of the electric sector, now under way in Brazil, ELETRONUCLEAR will remain part of ELETROBRAS due to the constitutional provisions mentioned in item 1.1 above.

The provision of funds for decommissioning activities is to be obtained from the ratepayers, and is included in the tariff structure, during the same period of depreciation of the plant (5%/year). For Angra 1, a reference decommissioning cost is currently estimated at 111 million dollars, which corresponds to about 10% of the construction cost.

4.2.2. Human resources

Adequate human resources are available for ELETRONUCLEAR from its own personnel or from contractors. Currently ELETRONUCLEAR has a total of 1840 employees in its permanent staff and a long-term contractor which supplies an additional 460 persons on a permanent basis. Of the total 2300 persons, 930 (40%) have a university degree, and 830 (36%) have a technical school certificate.

Activities related to qualification, training and retraining of plant personnel are performed by the Training and Simulator Department of ELETRONUCLEAR, which reports to the Operational Support Superintendent. Three facilities are available for training at the residential village close to the plant: a general training center, a training simulator for Angra 2, and a maintenance training center.

Angra 1 has no plant simulator. Operators for Angra 1 are trained in simulators of similar plants in the USA (Ginna Simulator) or Spain (Tecnatom Simulator). Simulator training load is of at least 60 hours per year for each individual. The composition of control room teams is specified in plant administrative procedures. The minimum control room team comprises a Shift Supervisor (who must hold a current Senior Reactor Operator - SRO licence), a Shift Foreman (also a SRO), a Reactor Operator (who must hold a Reactor Operator - RO licence) and a Balance of Plant Operator (also a RO). Although not required by CNEN, all Angra 1 Shift Supervisors are graduated engineers with five years of academic education.

The requirements for qualification for the entire Angra 1 staff are set forth in the FSAR pursuant to the principles of Standard ANSI 3.1 issued in 1978. In particular, the Plant Manager, the Deputy Plant Manager, the head of the Operation Department, the head of Technical Support, the Training Manager and the head of the Safety Team are currently licensed SROs or have previously held a SRO licence. The Radiation Protection Supervisor holds a special licence issued by CNEN, according to regulation CNEN-NE-3.03[8].

A full scope simulator for Angra 2 is available for training. Since the beginning of 1985 practical training of Brazilian specialists has been conducted. Instructors from ELETRONUCLEAR have also ministered classroom and practical training for operators, managers and licensing specialists from Germany, Spain, Argentina and Switzerland. With the imminence of the beginning of Angra 2 operation, qualification training for Angra 2 operators is currently under way. The first group of control room operators is scheduled to be licensed in the beginning of 1999.

Specialized training is also provided to the different groups of plant personnel. Maintenance technicians undergo a qualification programme according to their field of activity. Chemistry and radiological protection technicians follow extensive on-the-job training on a yearly basis aimed at a continuous updating of basic concepts learned during their initial technical training. The fire brigade and security personnel are trained according to the requirements established by related CNEN regulations.

Technical visits and reviews of ELETRONUCLEAR's training programme and training center by experts from the International Atomic Energy Agency (IAEA), the Institute for Nuclear Power Operation (INPO) and the World Association of Nuclear Operators (WANO) have provided valuable contribution to the identification and implementation of good practices for enhancing the quality of the training activities.

CNEN monitors the adequacy of the human resources of the licensee through the evaluation of its performance, especially through the analysis of the human factor influence on operational events. The training and retraining programme is also evaluated by CNEN as part of the licensing procedure and through regulatory inspections.

In the specific case of reactor operators, CNEN has established regulations for their authorization [6] and for their medical qualification[9]. CNEN conducts written and practical examinations for Reactor Operators and Senior Reactor Operators before issuing each individual authorization.

4.2.2.1. Technical capability of ELETRONUCLEAR in the design and construction areas

The Brazilian-German Agreement of 1975 provides for the transfer of the technology necessary to the activities of design, equipment manufacture, construction and operation of NPPs to Brazilian companies involved in the nuclear programme. Concerning Angra 2, the German party assumes technical responsibility for the jointly built plant.

For this purpose, several contracts have been signed by NUCLEN (now ELETRONUCLEAR), of which the most important is the Technical Information Contract, which provides for the necessary technology transfer. In the scope of this Contract, the following was accomplished (in round numbers):

- On-the-job training of Brazilian personnel in Germany: 250 engineers (550 man-years);
- German assignees in Brazil: 150 engineers, during the last 20 years;
- Documents transferred: 70.000.

In addition, 22 technology transfer contracts were signed with foreign traditional firms by different private Brazilian component suppliers. This assures a solid and continuous local technological basis for the design, construction and future operation of the Angra 2 plant and for the support of the operation of Angra 1.

4.3. Article 12. Human factors

Angra 1 was designed at a time when the human factor was not a prime issue in nuclear safety. Following the accident at Three Mile Island, and still before the commencement of operations, a critical review of plant design with respect to the man-machine interface was undertaken. This resulted in numerous modifications in the control room, including the installation of the Angra 1 Integrated Computer System (SICA) which encompasses a safety parameter display system for monitoring critical safety functions. At the same time, plant emergency operating procedures were greatly improved in their format, which now incorporate double columns, the left one dealing with the expected action and the right one with actions to be taken in case of inadequate response.

Later on, the human factor was considered in a much broader sense and several management initiatives were undertaken in this area, such as a programme for team-work training and a Human Performance Enhancement System (HPES). Training in safety culture aspects was also undertaken using IAEA guidelines.

CNEN evaluates the human factor through its assessment of root cause of operational events, through its review of the licensee's training programme, and through the operators licensing process.

Concerning the Angra 2 plant, CNEN has required, during the licensing process, that an additional chapter be included in the FSAR, specially addressing the human factor issue.

4.4. Article 13. Quality assurance

The requirement for a quality assurance programme in any nuclear installation project in Brazil is established in the licensing regulation [4]. Specific requirements for the programmes are established in a specific regulation, Quality Assurance for Nuclear Power Plants, CNEN-NE-1.16 [10], which is based in the IAEA code of practice 50-C-QA Rev.1. Quality Assurance for Nuclear Power Plants, but with the introduction of the concept of an Independent Technical Supervisory Organization (Organização de Supervisão Técnica Independente - OSTI)[11].

Former FURNAS and now ELETRONUCLEAR have established their quality assurance programmes according to these requirements. The corresponding procedures have been developed and are in use. The programme provides for the control of the activities influencing the quality of items and services important to safety. These activities include design, design modifications, procurement, fabrication, handling, shipping, storage, erection, installation, inspection, testing, operation, maintenance, repair, and training.

The Licensing, Environment Management and Quality Assurance Superintendence (PL), reporting directly to the Presidency (P), is responsible for the establishment and supervision of the ELETRONUCLEAR Quality System. A Committee for Nuclear Operation Analysis (CAON) is a collective body under the Operation and Commercialization Directorate (O) with the responsibility of reviewing and analyzing questions related to the operation of the nuclear power plants. A Plant Operation Review Committee (CROU) is a collective body under the Angra 1 Manager (OP1) whose purpose is to examine, follow-up and analyze issues concerning Angra 1 operational safety on closer a basis, and to make recommendations for improving safety.

The ELETRONUCLEAR quality assurance unit is responsible for performing internal and external audits in order to verify compliance with all aspects of the quality assurance programme. All audits are performed in accordance with written procedures. In case of internal audits, the persons involved with the activities being audited have no involvement in the selection of the audit team. Audit reports are distributed to, and formally reviewed by organizations responsible for the area being audited and also by the CAON.

Audits by CNEN ensure that quality assurance requirements are being implemented and that the quality assurance has been effective as a management tool to ensure safety.

4.5. Article 14. Assessment and verification of safety

A comprehensive safety assessment is a requirement established in the Brazilian licensing regulation.

Concerning the Angra 1 plant, both a Preliminary Safety Analysis Report (PSAR) and a Final safety Analysis Report (FSAR) were prepared in accordance with the requirements of US NRC Regulatory Guide 1.70 - Standard Format and Contents for Safety Analysis Report of LWRs. These reports were reviewed and assessed by CNEN, and in the case of the FSAR, extensive use was made of the US NRC - Standard Review Plan (NUREG - 0800).

The safety assessment included both deterministic and probabilistic approach to safety analysis. The deterministic approach followed the traditional western methodology using complex computer codes for the analysis of a large number of postulated events, ranging from minor transients to a large loss of coolant accident (LOCA). The probabilistic approach used probabilistic safety assessment (PSA) methodology. Although a full PSA was not a formal licensing requirement, a preliminary study was performed in 1983 using generic plant data. A new study is being developed, using plant specific reliability data, and more modern PSA methodology, and covering additional scenarios such as external events, fires and floodings.

Safety analysis report data are verified through the system of regulatory inspection, extensive commissioning test programme, and through the normal operational surveillance programme of the operator.

Concerning the Angra 2 plant, a larger amount of information was provided, but still a FSAR following the US NRC Regulatory Guide 1.70 format is being requested for the operation licence review. ELETRONUCLEAR is also planning to conduct a PSA for Angra 2.

4.6. Article 15. Radiation protection

Radiation protection requirements and dose limits are established in Brazil in the regulation for radiation protection[12]. These require that doses to which the public and the workers are exposed be kept below established limits and as low as reasonably achievable (ALARA).

Implementation of this regulation is performed by the basic plant design and through the establishment of a Health Physics Programme at each installation. Plant design is assessed at the time of the licensing review and by evaluating the dose records during normal operation.

The Health Physics Programme of Angra 1, included in the Final Safety Analysis Report, sets forth the philosophy and basic policy for radiation protection during operation. The highest level policy is to maintain personnel radiation exposure below the limits established by CNEN and to keep exposures to as low as reasonably achievable (ALARA), based on technical and economical considerations.

The annual exposure of workers is limited to a dose of 50 mSv for the effective dose equivalent, and 500 mSv for dose equivalent for individual organs and tissues, except in the case of the eye lens, the limit of which is 150 mSv. For women of reproductive capacity, the exposure is limited to a dose of 10 mSv for any quarter of the year, and, should they become pregnant, the limit is reduced to 1mSv for the extent of the pregnancy. These limits are in accordance with CNEN regulations, with applicable labor legislation that has endorsed CNEN limits, and with the international Convention n. 115 of the International Labor Organization (ILO), ratified by Brazil.

Release of radioactive material to the environment is controlled and kept below CNEN and IBAMA established limits, in accordance with administrative procedures. Additionally, the amount of radioactive waste and the radioactive effluents discharged into the environment also follow the ALARA principle.

A plant ALARA Commission composed of different groups (Operation, Maintenance, Chemistry, System Engineering and Radiation Protection) is in charge of implementing and monitoring the ALARA Programme that describes procedures, methodologies, processes, tools and steps to be taken in planning the work. The ALARA Programme has been continuously revised and represents the best effort to minimize occupational doses.

A Radiological Environmental Monitoring Programme, based on CNEN requirements, is conducted by ELETRONUCLEAR to evaluate the possible impact caused by the plant operation. This programme defines the frequency, places, types of samples and types of analyses for the survey of exposure rates. The evaluation of exposure rates is also made by direct measurement using thermoluminescent dosimeters distributed in cardinal sectors around the Angra site, and at points located in the nearest villages and cities. The results of the monitoring programme are compared with the pre- operational measurements taken, in order to evaluate any possible environmental impact. Semi- annual reports are presented to CNEN. To date no major environmental impact has been detected.

4.7. Article 16. Emergency preparedness

Brazil has established an extensive structure for emergency preparedness under the so- called System for Protection of the Brazilian Nuclear Programme (SIPRON). This includes organizations at the federal, state and municipal level involved with licensing and control activities as well as those organizations involved with public safety and civil defense. Operators of nuclear installations and facilities and supporting organizations are also part of SIPRON.

SIPRON was established by Law n. 1809 of October 7 1980. The Decree n. 2210 of April 22 1997 established the Secretary for Strategic Affairs (SAE), directly linked to the Presidency, as the central organization of SIPRON. This decree also establishes a Coordination Commission (COPRON) composed of representatives of several governmental agencies involved. Besides ELETRONUCLEAR, as the operator, and CNEN, as the nuclear regulatory body, other agencies are involved as support organizations, such as the municipal civil defense, the state civil defense, the Angra Municipality, the IBAMA, the National Road Department (DNER), the National Army, Navy and Air Force, and the Ministries of Health, External Relations, Justice, Finance, Planning and Budget, Transportation, and Communications (see Attachment 1E).

Within SIPRON, SAE issued a General Norm for Emergency Response Planning (SIPRON- NG-02)[13] and has prepared specific guidelines for Angra site emergency planning (Diretriz Angra 1) [14], consolidating all requirements of related national laws and regulations and stating the responsibilities of each of the involved organizations. Additional norms related to emergency centers, communications, and information to the public were also issued by SAE.

At the plant level, a comprehensive Emergency Plan has been established and is periodically tested. The plan involves several levels of activation, from single alert status, through area emergency, to a general emergency. Dedicated facilities at the plant site and in the local region have been designated and, with the assistance of the licensee, the local civil defense equipment for emergencies has been greatly upgraded.

Corresponding plans for CNEN, its support Institute for Radiation Protection and Dosimetry (IRD) and other involved agencies have been prepared, and detailed procedures have been developed and are being revised.

The presence of more than 7000 workers at the Angra site, due to the construction of Angra 2, has created a peculiar temporary situation that hampers immediate emergency response.

In 1996, after a review of the existing plans and comparing with information obtained during the observation of an emergency exercise in the United States by a SIPRON working group, substantial changes were introduced in the emergency response approach. After these modifications were introduced, in 1997, SAE coordinated two partial exercises and a general emergency exercise. The general emergency exercise established 20 objectives to be demonstrated and evaluated to verify and validate the adopted systematic approach. The exercise was observed by international experts from the IAEA and Argentina, who prepared a report [15] which concluded that the exercise achieved most of its objectives.

Regarding information to the public, SIPRON norm NG-05[16] establishes the requirements for public information campaigns about emergency plans. The first public information campaign was conducted by FURNAS in 1982 before the first criticality of Angra 1 was attained. Several other campaigns have been conducted. The last campaign in 1997 combined information on both on-site and off-site emergency plans, including the population living in the 15-km area around the plant. This campaign included the distribution of informative material on a house-to-house basis, to local newspaper, radio, TV, buses and bus stations, schools, community association, churches, and administrative offices. These campaigns are conducted by personnel from the federal, state and municipal civil defense, state fire brigade, ELETRONUCLEAR volunteers, and CNEN and ELETRONUCLEAR technical and public information personnel. Preceding every siren test or a general emergency exercise, specific flyers are distributed in affected areas and handed along main routes to passing drivers and buses, and vehicles fitted with loudspeakers circulate through villages making announcements to ensure that all residents have been properly informed.

It should be noted that, due to the particular geographical situation of the Angra plant, no radiological impact is likely to occur in any neighboring countries, even in the improbable event of a major release. Notwithstanding that fact, Brazil has signed both the Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in Case of a Nuclear Accident or Radiological Emergency, and a bilateral agreement with Argentina for notification and assistance in case of a nuclear accident.

Chapter 5 - SAFETY OF INSTALLATIONS

5.1. Article 17. Siting

The Brazilian siting regulation CNEN 09/69[5] requires a site approval before the issuance of a construction authorization. The Angra site has already been approved for the 3 units. Site parameters are further evaluated during the PSAR preparation and review and are taken into consideration in the plant design.

For the Angra 1 plant, whose construction began in 1972, the environmental impact was not formally evaluated before site approval, since no related regulations existed at the time. The environmental impact was assessed at the time of the operating licence by FEEMA as described in 3.1. above.

Since the promulgation of Law 6938 of August 31 1981, which establishes the National Policy on the Environment (PNMA), "the construction, installation, expansion and operation of facilities or activities which cause or may cause pollution or are capable of causing environmental degradation" requires an environmental licence. This involves the elaboration of an Environmental Impact Study (EIA) and the preparation of an Environmental Impact Report (RIMA) before site approval. Considering that the site of Angra nuclear power plant was already in use for a nuclear unit, the environmental licensing of Angra 2 included the preparation of an EIA/RIMA only for the operation licence. These documents are currently being reviewed by IBAMA in cooperation with CNEN. The RIMA will constitute the main document to be discussed during the public hearings scheduled for the end of 1998, within the environmental licensing process.

With respect to Angra 1, site parameters continue to be evaluated during plant operation, especially those related to the demographic distribution with respect to emergency preparedness. An updating of the detailed population census in the vicinity (5-km radius) of the power plant was conducted in 1996.

5.2. Article 18. Design and construction

The design of the Brazilian nuclear power plants is based on established nuclear technology in countries with more advanced programmes. The licensing regulation CNEN-NE-1.04[4] formally requires the adoption of a "reference plant" which shall have a similar power rating, be under construction in the country of the main contractor, and go into operation with sufficient time to allow for the use of the experience gained from pre-operational tests and initial operation.

Therefore, Angra 1 was designed and constructed with US technology, which incorporates the concept of defense in depth, including the use of multiple barriers against the release of radioactive material. Extensive use was made of US codes and guides such as ASME 3, ASME 11, IEEE standards, ANSI standards and US NRC Regulatory Guides. Operating experiences from US plants, especially the fire at Browns Ferry and the accident at Three Mile Island, were incorporated through modification of the design, during the construction phase. Design review and assessment were performed through preparation by FURNAS and its contractors of a PSAR and a FSAR, which were evaluated by CNEN during the licensing process.

Construction adopted a quality assurance programme, which encompassed all activities related to safety conducted by FURNAS and its contractors and subcontractors. CNEN monitored the implementation of the quality assurance programme through the regulatory inspection programme and by establishing of a resident inspector group during the construction phase.

In a similar manner, Angra 2 has been designed and is being constructed with German technology, within the framework of the comprehensive technology transfer agreement between Germany and Brazil. The plant is "referenced" to the Grafenrheinfeld nuclear power plant, currently in operation in Germany. The problem of the long construction delay has been addressed through a continuous updating of the design, incorporating feedback from operational experience from German and other countries' nuclear power plants, and new licensing requirements in Brazil and Germany. The problem of the long period of storage for early manufactured components was dealt with by an appropriate and careful storage process, which involved adequate packing, storage, monitored environmental conditions and a periodical inspection programme. The storage programme and procedures were reviewed by an international group of experts from the IAEA in 1994, with positive results[17].

5.3. Article 19. Operation

5.3.1. Item i. Initial authorization

The operation of a nuclear power plant in Brazil is subject to two formal steps of approval steps by CNEN within the regulatory process: authorization for initial operation (AOI) and authorization for permanent operation (AOP).

The authorization for initial operation is issued after the completion of the review and assessment of the Final Safety Analysis Report (FSAR), and takes into consideration the results of regulatory inspections carried out during the construction and pre-operational test period. Additionally, it requires the operator to have prior authorization for utilizing nuclear materials; a physical protection programme in accordance with CNEN regulations; an emergency plan in accordance with SIPRON regulations; and financial guarantees regarding the legislation on civil liability. Simultaneously, the corresponding environmental licence must be obtained from IBAMA, in accordance with the national environmental legislation.

The authorization for permanent operations, in addition to the AOI requirements, is based on the review of the start up test results. Safety requirements during operation are established by regulation CNEN-NE-1.26[18].

Operation is monitored by CNEN through an established system of periodical reports [7], notification of safety-related events and through the regulatory inspection during operation. The site houses a group of CNEN resident inspectors. Similar monitoring regarding the environmental impact is performed by IBAMA.

5.3.2. Item ii. Limits and conditions for operation

Limits and conditions for operation are proposed by the applicant in the FSAR, reviewed and approved by CNEN during the licensing process, and referenced in the licence document. No changes in these limits and conditions shall be made by the licensee without prior approval by CNEN.

5.3.3. Item iii. Operation, maintenance, inspection and testing

Safety requirements during operation are established by regulation CNEN- NE- 1.26 [18]. Additional CNEN regulations establish more detailed requirements for maintenance[19] and in service inspection[20].

The implementation of these requirements at the plant is achieved through the preparation of an Operation Manual, which contains guidelines for developing, approving and controlling plant procedures according to the nuclear class and the Quality Assurance programme. It also contains the actual procedures for all activities to be conducted in the plant concerning operation, maintenance, inspection and testing.

An administrative procedure (Organization of the Operation Manual) provides the detailed requirements for developing, approving and controlling all plant procedures. In the case of surveillance procedures required by the Technical Specifications or the ASME Code, another administrative procedure provides more detailed instructions regarding the elaboration, accomplishment and control of procedures. The Plant Operation Review Commission (CAON) analyses and approves all nuclear safety class procedures and those that are related to the Quality Assurance programme.

All employees must follow written procedures, and each Department Manager (Operation, Maintenance, Technical Support, Chemistry, Health Physics, etc), must make certain that all tasks performed under his/her responsibility are accomplished following the latest review of the approved procedure. The Quality Assurance Department monitors and controls whether the plant's organizational scheme is respectful of approved procedures during operation, maintenance, testing and inspection.

The Operation Manual is divided into volumes according to specific areas of activity, such as: Administrative, Operation, Chemistry and Radio Chemistry, Reactor Performance, Nuclear Fuel, Instrumentation, Electrical and Mechanical, Health Physics, Surveillance, Training, Physical Protection, Emergency Procedures, Fire Protection, Environmental Monitoring. Included in the Operation volume are the Emergency Operation Procedures and Abnormal Procedures for assisting in abnormal and accidental events. Specific procedures are also issued for cases of welding, when qualified persons and materials are made necessary. The procedures should be reviewed every 2 years.

Temporary procedures are necessary for cases where hired companies (foreign or national) perform work in the plant. For a contracted company that develops its own procedures, a plant expert or an engineer whose expertise relates to the work being performed analyses the original procedure and send the results to the Quality Assurance, so that the latter may check if it meets the acceptance criteria. A cover sheet with an approval form is attached to the procedure forwarded to Quality Assurance.

In case of other temporary procedures, the author of the procedure must write an explanation of its temporary nature and establish a validation period. Temporary procedures can be used only during the validated period stamped on the procedural form.

The Work Control Group is responsible for planning all the maintenance, inspection and testing tasks. Inside the work package, procedures, plant modification documents, part lists and other references applicable to the task should be included. Two more steps are necessary for actually beginning a task: the discussion at the daily co- ordination meeting and the shift supervisor approval.

As a part of the work control process, one stamps the "Work Permit" with a "Red Line" to identify tasks involving nuclear safety equipment. In this case, quality assurance and maintenance quality control personnel ensure that approved procedures and part lists with traceability are being used. In addition, for equipment with a "Risk of Scram", an approved procedure with a "Red Cover Sheet" must be followed so as to warn workers of the risks and cautions to be taken.

During outages, a written and approved outage procedure controls the overall plant safety condition for inspection, testing and refuelling operation.

Operational safety is monitored by CNEN through the regulatory inspection programme and by the routine surveillance carried out by the resident inspector's group. Within ELETRONUCLEAR, corporate auditing is conducted by the Quality Assurance Department, and reviewed by the CAON. Additionally addition, periodical peer review is conducted voluntarily by the operator, by inviting international review missions from INPO, WANO and the IAEA (see Annex 4 for a list of international technical review missions conducted at the Angra plant).

5.3.4. Item iv. Procedures for responding to anticipated operational occurrences and accidents.

As mentioned in item 5.3.3, the Angra 1 Operation Manual contains procedures for emergencies and abnormal situations that must be used in responding to anticipated operational occurrences and accidents. In cases of abnormal conditions, procedures are followed so as to return the plant to normal conditions as soon as practical or to bring the plant to a safe state, such as hot shutdown or cold shutdown. For accidents, Emergency Operating Procedures (EOPs) were written by taking into account the latest reactor manufacturer guidelines and current international practices. Emergency Operating Procedures are supplemented by Subsequent Emergency Procedures and Contingency Emergency Procedures.

An Integrated Computerized System, added to Angra 1 after initial operation, assists the operator in monitoring Critical Safety Functions (CSF) and other process variables. When a CSF (Subcriticality, Core Cooling, Coolant Inventory, Containment Integrity, and Heat Sink) is violated or there is a possibility that the specified limits will be reached, approved procedures exist to restore the CSF to its normal condition. Colour codes used in the Integrated Computerized System help the operators to act in a preventive manner to avoid reaching the protection limits. These colours (green - Normal, yellow - Alert, Orange - urgent, Red - Emergency) guide the operator in selecting the procedure to be followed. In case the Integrated Computerized System is not operable, there is a procedure that must be followed by the operator to check if any CSF has been, or is in the process of being violated.

5.3.5. Item v. Engineering and technical support

Engineering services and technical support are available for the operation of Angra 1 within the ELETRONUCLEAR organization and are supplemented by outside contractors. The technical support groups cover all basic engineering fields: civil, electrical, mechanical, instrumentation and control, systems and components, stress analysis, reactor physics, and radiation protection. In this respect, the creation of ELETRONUCLEAR, combining FURNAS engineering and technical support groups with NUCLEN design capability, has significantly improved the support services available to both Angra 1 and Angra 2 (see item 4.2.2.1).

These groups are involved with the operational analysis, evaluation of operational experience feedback and system performance, which usually lead to plant modifications. The regulatory body also demands occasional modifications, after periodical updating of its regulations, by taking into account new technological developments, feedback from operational experience and new international practices.

5.3.6. Item vi. Reporting of significant incidents

Reporting requirements during operations are established in regulation CNEN- NE- 1.14 [7].

Different types of reports are established, such as periodical reports and reports of abnormal events. Immediate notification is required for events which involve the degradation of the plant safety conditions, or exposure to radiation of site personnel or the public at levels beyond the established limits. Other events should be reported within 24 hours or 30 days, depending on their safety significance.

The International Nuclear Events Scale (INES) is used to classify the safety significance of the events. No event of INES level 1 was reported in 1996/97. In 1996, Angra 1 reported to CNEN six (6) events of INES level 0. In 1997 this number increased to nineteen (19), all of which had minor significance, except for the problem resulting from the re-occurrence of fuel degradation as mentioned in item 2.1.1.

5.3.7. Item vii. Operating experience feedback

The operational experience feedback process in Brazil comprises two complementary systems: one performed by the utility, which processes both in-house and external information, and one performed by CNEN.

An Operational Experience Analysis Group was established by FURNAS and continues to operate under ELETRONUCLEAR. This group investigates relevant incidents occurred in Angra 1 and in similar nuclear installations in order to make recommendations. A programme to collect operating experience has been established using several sources of information, such as INPO, WANO and Owners Groups. In addition, technical exchange visits conducted periodically constitute a valuable source of information on other plant experiences (see Annex 4 for a list of international missions related to the Angra plant).

CNEN itself has its own system for operational experience feedback, by which it can analyze Angra 1 events and actively participate in international organizations to share its own operating experience, as its has done under the auspices of the International Reporting System (IRS) of the IAEA. To date, Brazil has reported 10 events to IRS. CNEN transfers the relevant IRS reports it receives to the operator for evaluation. The feedback loop is thereby completed.

5.3.8. Item viii. Radioactive waste and spent fuel

The Angra 1 nuclear power plant is equipped with systems for the treatment and conditioning of liquid, gaseous and solid wastes. Liquid wastes are solidified in concrete and conditioned in 55-gallon drums. Solid wastes may be conditioned in drums or in special boxes. Gaseous wastes are stored in holdup tanks and may be released from time to time. These tanks have the capacity for long term storage, which eliminates the need for scheduled discharge. For the time being, medium and low level wastes are being stored on site in a separate storage facility.

Generated volume of solid radioactive waste material is kept to a minimum by preventing materials from becoming radioactive, by decontaminating and reusing radioactive materials, by monitoring them for radioactivity and by separating non-radioactive material prior to conditioning and storage, and by other volume reduction techniques. Procedures, personnel training and quality control checks are used to ensure that radioactive materials are properly packed, labeled and transported to the storage facility.

With respect to the spent fuel of Angra 1, an expansion of the spent fuel pool capacity has been performed by the installation of compact racks to accommodate the spent fuel generated for the expected operational life of the unit.

Chapter 6. PLANNED ACTIVITIES TO IMPROVE SAFETY

Safety culture entails a questioning attitude and a search for excellence. Therefore, notwithstanding the good Brazilian record on safety, the country's nuclear operators and regulators are constantly working on improvements in this area.

At present, CNEN works in the approval of a bill of law that would establish licence fees and taxes (see item 3.2) that could help relieve the constant fund shortage of a regulatory body whose scope of activity is ever increasing. In addition, a bill of law is under discussion that would establish administrative and monetary penalties for all nuclear facilities and services that registered cases of non-compliance. Such measures are expected to strengthen the enforcement powers of CNEN.

The Authorization for Permanent Operation of Angra 1 established a realistic schedule for the realization by the operator of a series of improvements. These include the development of a Plant Aging Management Programme and a Maintenance Efficiency Programme. Furthermore, CNEN regulation NE 1.26 [18] requires a periodical safety review after every ten- year period of operation, which is expected to be an opportunity for reviewing past performance and for upgrading the plant, to the extent possible, in accordance with current safety requirements.

Current activities at the plant with the view to improving nuclear safety include the review and expansion of the Probabilistic Safety Assessment (PSA) for Angra 1 (see 4.5), and the review of the technical specifications for operation, so as to adapt them to current international practice.

With respect to emergency planning, a task force has been created to introduce a quality assurance programme for organizations involved in SIPRON, to the extent possible. Additionally, formal agreements have been signed to provide the civil defenses of Angra Municipality and of Rio de Janeiro State with an improved infrastructure for public shelters, health care and other measures related to emergency preparedness.

Chapter 7. FINAL REMARKS

Given the safety performance of nuclear installations in Brazil, and considering the information provided in this National Report, the Brazilian nuclear organizations consider that the following characterizes the record of the country's nuclear programme:

- the achievement and maintenance of a high level of safety in its nuclear installations;
- the establishment and maintenance in its nuclear installations of effective defenses against potential radiological hazards so as to protect individuals, the society and the environment from the harmful effects of ionizing radiation;
- the ability to prevent accidents with radiological consequences, and preparedness for mitigating the consequences of such accidents should they occur.

Brazil thus considers that its nuclear programme has met the principles and objectives set forth by the Convention on Nuclear Safety.

REFERENCES

1. Convention on Nuclear Safety - Legal Series No. 16 - International Atomic Energy Agency - Vienna - 1994.
2. Guidelines Regarding National Reports under the Convention on Nuclear Safety - CNS/PREP/FINAL DOCUMENT 2 - 1997.04.24.
3. Power Reactor Information System - International Atomic Energy Agency (available through the Internet at http://iaea.or.at).
4. Licensing of Nuclear Installations - CNEN-NE-1.04 - July 1984.

5. Siting of Nuclear Power Plants - Resolution CNEN 09/69.
6. Licensing of Nuclear Reactor Operator - CNEN-NN-1.01 - October 1979.
7. Operational Reporting for Nuclear Power Plants - CNEN-NE-1.14 - 1983.
8. Certification of Qualification of Radiation Protection Supervisors - CNEN-NN-3.03 - October 1997.
9. Health Requirements for Nuclear Reactor Operators - CNEN-NN.1.06 - 1980.
10. Quality Assurance in Nuclear Power Plants - CNEN-NE-1.16 - December 1994.
11. *Independent Technical Supervision in Quality Assurance Activities in Nuclear Power Plants* - CNEN-NN-1.15 - September 1986.
12. Basic Radiation Protection Directives - CNEN-NE-3.01 - August 1988.
13. General Norm for Planning of Response to Emergency Situations - SIPRON - NG-02 - 1996
14. Directive for the Preparation of Emergency Plans related to the Unit 1 of Almirante Alvaro Alberto Nuclear Power Plant - SIPRON Directiva Angra - 1997.
15. Report on the Emergency Planning Exercise at Angra - IAEA - BRA/9/042 - June 1997.
16. General Norm for Establishing Public Information Campaigns about Emergency Situations - SIPRON - NG-05 - 1997.
17. Long Term Storage of Equipment - IAEA - BRA/9/043-01 - Report RU 4929 - 1994.
18. Operational Safety in Nuclear Power Plants - CNEN-NE-1.26 - October 1997.
19. Maintenance of Nuclear Power Plants - CNEN-NE-1.21 - August 1991.
20. In-service Inspection of Nuclear Power Plants - CNEN-NE-1.25 - September 1996.

Annex 1

EXISTING INSTALLATIONS

1.1. Angra 1

Thermal power 1876 Mwth

Gross electric power 657 Mwe

Net Electric power 626 Mwe

Type of reactor PWR

Number of loops 2

Number of turbines 1 (1High Pressure/2Low pressure)

Containment Dry cylindrical steel shell and external concrete building.

Fuel assemblies 121

Main supplier Westinghouse El. Co.

Architect Engineer Gibbs & Hill / Promon Engenharia

Civil Contractor Construtora Norberto Odebrecht

Mechanical Erection Empresa Brasileira de Engenharia

Construction start date March 1972

Core load 20 September 1981

First criticality 13 March 1982

Grid connection 1 April 1982

Commercial operation 1 January 1985

1.2. Angra 2 (and 3)

Thermal Power 3765 MWth

Gross electric power 1309 MWe

Net electric power 1229 Mwe

Type of reactor PWR

Number of loops 4

Number of turbines 1 (1High Pressure/3Low pressure)

Containment Dry spherical steel shell and external concrete building.

Fuel assemblies 193

Main supplier Siemens KWU

Architect Engineer ELETRONUCLEAR/Siemens KWU

Civil Contractor Construtora Norberto Odebrecht

Mechanical Erection Unamon

Construction start date 1975 (Angra 3 - 1978)

Core load (scheduled) June 1999 (Angra 3- 2005)

Grid connection (") October 1999 (Angra 3- 2005)

Commercial operation (") December 1999 (Angra 3 - 2005)

Annex 2

LIST OF RELEVANT LAWS, CONVENTIONS AND REGULATIONS

2.1. Relevant National Laws

Decree 40.110 of 1956.10.10 - Creates the Brazilian National Commission for Nuclear Energy (CNEN).

Law 4118/62 of 1962.07.27 - Establishes the Nuclear Energy National Policy and reorganizes CNEN.

Law 6189/74 of 1974.12.16 - Creates Nuclebras as a company responsible for nuclear fuel cycle facilities, equipment manufacturing, nuclear power plant construction, and research and development activities.

Law 6.453 of 1977.10.17 - Defines the civil liability for nuclear damages and criminal responsibilities for actions related to nuclear activities

Decree 1809 of 1980.10.07 - Establishes the System for Protection of the Brazilian Nuclear Programme (SIPRON).

Law 6938 of 1981.08.31 - Establishes the National Policy for the Environment (PNMA), creates the National System for the Environment (SISNAMA), the Council for the Environment (CONAMA) and Brazilian Institute for the Environment (IBAMA).

Law 7781/89 of 1989.06.27 - Reorganizes the nuclear sectors.

Decree 99.274 of 1990.06.06 - Regulates application of law 6938, establishing the environmental licensing process in 3 steps: pre-licence, installation licence and operation licence.

Decree 2210 of 1997.04.22 - Regulates SIPRON, defines the Secretary for Strategic Affairs (SAE) as the central organization of SIPRON and creates the Coordination of the Protection of the Brazilian Nuclear Programme (COPRON).

2.2. Relevant International Conventions of which Brazil is a Party

Convention on Civil Liability for Nuclear Damage (Vienna Convention). Signature: 23/12/1993. Entry into force: 26/06/1993.

Convention on the Physical Protection of Nuclear Material. Signature:15/05/1981. Entry into force: 8/02/1987.

Convention on Early Notification of a Nuclear Accident Signature: 26/09/1986. Entry into force: 4/01/1991.

Convention on Assistance in Case of Nuclear Accident or Radiological Emergency. Signature: 26/09/1986. Entry into force: 4/01/1991.

Convention on Nuclear Safety. Signature: 20/09/1994. Entry into force: 24/04/1997.

Convention n. 115 of the International Labor Organization. Signature: 7/04/1964.

2.3. CNEN Regulations

NE 1.04 - Licenciamento de instalações nucleares - Resol. CNEN 11/84 - ***(Licensing of nuclear installations).***

NE 1.14 - Relatórios de operação de usinas nucleoelétricas - ***(Operation reports for nuclear power plants).***

NE 1.16 - Garantia de qualidade para usinas nucleoelétricas - Resol. 10/84 - ***(Quality assurance for nuclear power plants).***

NE 1.17 - Qualificação de pessoal e certificação para ensaios não destrutivos em itens de instalações nucleares - ***(Qualification and certification of personnel for non-destructive tests in nuclear power plants components).***

NE 1.18 - Conservação preventiva em usinas nucleoelétricas - ***(Preventive conservation of nuclear power plants).***

NE 1.19 - Qualificação de programas de cálculos para análise de acidentes de perda de refrigerante em reatores a água pressurizada - Resol. CNEN 11/85 - ***(Qualification of calculation programs for the analysis of loss of coolant accidentes in pressurized water reactors).***

NE 1.20 - Aceitação de sistemas de resfriamento de emergência do núcleo de reatores a água leve - ***(Acceptance criteria for emergency core cooling system for light water reactors).***

NE 1.21 - Manutenção de usinas nucleoelétricas - ***(Maintenance of nucelar power plants).***

NE 1.22 - Programas de meteorologia de apoio de usinas necleoelétricas - ***(Meteorological programme in support of nuclear power plants).***

NE 1.25 - Inspeção em serviço de usinas nucleoelétricas - ***(In service inspection of nuclear power plants).***

NE 1.26 - Segurança na operação de usinas nucleoelétricas - ***(Operational safety of puclear power plants).***

NN 1.01 - Licenciamento de operadores de reatores nucleares - Resol. CNEN 12/79 - ***(Licensing of nuclear reactor operators).***

NN 1.06 - Requisitos de saúde para operadores de reatores nucleares - Resol. CNEN 03/80 - ***(Health requirements for nuclear reactor operators).***

NN 1.12 - Qualificação de órgãos de supervisão técnica independente em instalações nucleares - Resol. CNEN 16/85 - ***(Qualification of independent technical supervisory organizations for nuclear installations).***

NN 1.15 - Supervisão técnica independente em atividades de garantia da qualidade em usinas nucleoelétricas - ***(Independent technical supervision in quality assurance activities in nuclear power plants).***

NE 2.01 - Proteção física de unidades operacionais da área nuclear - Resol. CNEN 07/81 - ***(Physical Protection in operational units of the nuclear area).***

NE 2.03 - Proteção contra incêndio em usinas nucleoelétricas - Resol. CNEN 08/88 - ***(Fire protection in nuclear power plants).***

NE 3.01 - Diretrizes básicas de radioproteção - Resol. CNEN 12/88 - ***(Radiation protection directives).***

NE 3.02 - Serviços de proteção radiológica - ***(Radiation protection services).***

NE 3.03 - Certificação da qualificação de supervisores de radioproteção - Resol. CNEN 09/88 - ***(Certification of the qualification of radiation protection supervisors).***

NE 5.01 - Transportes de materiais radioativos - Resol. CNEN13/88 - ***(Transport of radiaoctive materials).***

NE 5.02 - Transporte, recebimento, armazenamento e manuseio de elementos combustíveis de usinas nucleoelétricas - ***(Transport, receiving, storage and handling of fuel elemets in nuclear power plants).***

NE 5.03 - Transporte, recebimento, armazenagem e manuseio de ítens de usinas nucleoelétricas - ***(Transport, receiving, storage and handling of items in nuclear power plants).***

NE 6.05 - Gerência de rejeitos radioativos em instalações radioativas - ***(Radioactive waste management in nucelar installations).***

2.4. CONAMA Regulations

CONAMA - 01 - Estabelece requisitos para execução do Estudo de Impacto Ambiental (EIA) e do Relatótio de Impacto Ambiental (RIMA) - ***(Establishes requirements for conducting the environmental study (EIA) and the preparation of the report on environmental impact(RIMA))*** - (23/01/1986).

CONAMA-28 - Determina a FURNAS a elaboração de EIA/RIMA para as usinas nucleares de Angra 2 e 3 - ***(Directs FURNAS to prepare an EIA/RIMA for the Angra 2 and 3 nuclear power plants)*** - (03/12/1986)

CONAMA-09 - Regulamenta a questão de audiências públicas - ***(Regulates the matters related to public hearings)*** - (03/12/1987).

2.5. SIPRON Regulations

NG- 01 - Norma Geral para o funcionamento da Comissão de Coordenação da Proteção do Programa Nuclear Brasileiro (COPRON) - ***(General norm for the Coodination Commission for the Protection of the Brazilian Nuclear Program).*** Port. SAE 99 of 13.06.1996.

NG-02 - Norma Geral para planejamento de resposta a situações de emergência. - ***(General norm for planning of response to emergency situations).*** Resol. SAE/COPRON 01/96.

NG- 03 - Norma Geral sobre a integridade física e situações de emergência nas instalações nucleares - ***(General norm for physical integrity and emergency situations in nuclear installations).*** Resol. SAE/COPRON 01/96.

NG- 05 - Norma Geral para estabelecimento de campanhas de esclarecimento prévio e de informações ao público para situações de emergência - ***(General norm for establishing public information campaings about emergency situations).*** Port. SAE 150 of 11.12.1992.

NG- 06 - Norma Geral para instalação e funcionamento dos centros de resposta a situações de emergência nuclear - ***(General norm for installation and functioning of response center for nuclear emergency situations).*** Port. SAE 27 of 27.03.1997.

NG- 07 - Norma Geral para planejamento das comunicações do SIPRON ***(General norm for SIPRON communication planning).*** Port. SAE 37 of 22.04.1997.

Diretriz Angra- 1 - Diretriz para elaboração dos planos de emergência relativos a unidade 1 da Central Nuclear Almirante Álvaro Alberto - ***(Diretive for the preparation of emergency plans related to Unit 1 of Almirante Alvaro Alberto Nuclear Power Plant - Angra 1).*** Port. SAE 144 of 20.11.1997.

Annex 3

MAIN MODIFICATIONS AT ANGRA 1

Completed:

1. Improvements in the charging system of Chemical and Volume Control System (CVCS) to increase its reliability.
2. New on-site provisional storage facility for radioactive wastes.
3. Installation of on-line gaseous effluent radiation monitor in the vent stack, for normal and accident conditions.
4. Implementation of fire hazards programme.
5. Installation of post-LOCA sampling system.
6. Implementation of Angra Integrated Computer System (SICA).
7. Installation of continuous condenser cleanup system.
8. Installation of reactor cavity decontamination system.
9. Installation of cold overpressurization protection system, using the PORV's.
10. Enlargement of administration building to install SICA data processing system.
11. Installation of Nitrogen inertization system for secondary components.
12. Installation of reactor cavity filtration system, for improvement of visibility during reloading.
13. Retubing of main condenser with Titanium tubes.
14. Installation of reactor head venting system.
15. Implementation of a technical support centre.
16. Installation of on-line H_2/O_2 containment monitoring system, for normal and accident conditions.
17. Modification on the waste encapsulation system, with extension of the monorail.
18. Installation of 2 additional Diesel Generators (DG 3 and 4).
19. Installation of heat-up and cooldown rate monitoring system for pressurizer and primary system.
20. Modification of steam generators maintenance platforms for improved access.
21. Replacement of all static inverters.
22. Modifications on moisture separators re-heaters.
23. Protection of main electric generator against high magnetic flux density.
24. Installation of new portal monitors at the controlled area entrance.
25. Re-enforcement of mechanical penetration anchorage on the main steam lines.
26. Improvements on the main electric generator.
27. Installation of instrumentation for separators and re-heaters performance monitoring.
28. Installation of middle loop operation level monitoring system.
29. Installation of ATWS mitigation system.
30. Installation of super-compact storage racks in the spent fuel pool.
31. Modification in the Diesel generators 3 and 4 heat exchangers to use seawater.
32. Refurbishing of the demineralized water station.
33. Doubling of fire protection main water line.
34. Installation of waste compactation system with 15 ton capacity.
35. Installation of reactor inventory monitoring system (SMIR).
36. Improvements on secondary chemistry monitoring system.
37. Installation of fuel element failure detection system (in-mast fuel sipping system).
38. Substitution of reactor coolant filters for improved design.
39. Improvements with respect to station blackout rule.
40. Installation of pressurizer safety valve position indicator (monitoring and alarm).
41. Improvements in the gripper of manipulator crane.
42. Replacement of electric battery banks 1E, 1D1 and 1D2.
43. Installation of new cold chemistry laboratory.
44. Implementation of a radioactive waste minimization programme.
45. Enlargement of dressing room and installation of a new laundry room.
46. Qualification of hot and cold leg temperature detectors.

47. Installation of heat tracing in pressurizer relief line.
48. Installation of activity indicators in AI-J and AI-K panels.

Current:

1. Replacement of containment electric penetrations E-2, E-8 and E-11.
2. Replacement of feedwater heaters.
3. Expansion of meteorological monitoring system.
4. Substitution of obsolete instrumentation.
5. Installation of instrumentation according to requirements of Reg.Guide 1.97.
6. Modify alarm board to operate with no lighted alarms.
7. Alternative cooling system for spent fuel pool.
8. Installation of new chlorination station for service water and circulating water systems.
9. Implementation of a radioactive waste recipient qualification programme.
10. Increase of component cooling drainage capacity.
11. Development and qualification of procedures for re-encapsulation of defective radioactive waste drums.

Annex 4

INTERNATIONAL TECHNICAL MISSIONS

RELATED TO ANGRA NUCLEAR POWER PLANT

N.	*Year*	*Mission*	*Subject*
1	1985	OSART IAEA	Operational Safety Review - Angra 1
2	1988	Inpection Nucleaire - EDF	Operational Safety Review - Angra 1
3	1988	ASSET IAEA	Operational Experience Feedback - Angra 1
4	1989	INPO	Technical Exchange Visit - Angra 1
5	1989	OSART IAEA	Operational Safety Review - Angra 1

6	1992	INPO	Technical Exchange Visit - Angra 1
7	1992	OSART IAEA	Operational Safety Review - Follow-up Mission- Angra 1
8	1992	INPO	Maintenance Assistance Visit - Angra 1
9	1992	ASSET IAEA	Assessment of Safety Significant Events - Angra 1
10	1993	WANO	Peer Review - Angra 1
11	1994	EDF	Technical Exchange Visit of Shift Supervisors in Training - Angra 1 (request through WANO)
12	1994	INPO	Technical Exchange Visit in Operational Technical Support and Root Cause Analysis
13	1995	IAEA RLA/4/012	Technical Visit from Argentina, Mexico and Cuba on Equipment Preservation During Construction -Angra 2
14	1995	INPO	Technical Exchange Visit on Outage Co-ordination - Angra 1
15	1995	INPO	Assistance Visit on the Area of Maintenance - Angra 1
16	1995	IAEA RLA/4/012	Executive meeting with Plant Managers of Atucha, Angra, Laguna Verde and Juragua
17	1996	INPO	Assistance Visit to Technical Division System Engineering Organization - Angra 1
18	1996	WANO	General Peer Review - Angra 1

Attachment 1

ORGANIZATION CHARTS

(Only in the original document)

1.A. BRAZILIAN NUCLEAR ORGANIZATIONS

1.B. CNEN ORGANIZATION

1.C. ELETRONUCLEAR ORGANIZATION

1.D. IBAMA ORGANIZATION

1.E. SIPRON STRUCTURE

ATTACHMENT 2

ELETRONUCLEAR SAFETY POLICY

(Available only in Portuguese, upon request)

This report was prepared by a task force composed of representatives of the following organizations:

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Eletrobrás Termonuclear S.A. (ELETRONUCLEAR)

Instituto Brasileiro do Meio Ambiente a dos Recursos Naturais Renováveis (IBAMA)

Ministério de Relações Exteriores (MRE)

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